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**DESCRIPTIONS OF OBSERVATIONS
OF LUNAR VOLCANOES IN THE
18TH AND EARLY 19TH CENTURIES**

by T. N. Klado

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IN THE 18TH AND EARLY 19TH CENTURIES

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v XVIII i nachale XIX vv."
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DESCRIPTIONS OF OBSERVATIONS OF LUNAR VOLCANOES IN
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ABSTRACT

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The report presents briefly the outstanding theories of the last 200 years on the question of the existence of lunar volcanoes, from Herschel to the present.

The author compares the propositions of leading investigators as represented by their own documents and letters, in which they defend their own propositions, describe their research methods and findings, and refute or defend others.

The author in turn offers explanations, in perspective, to disprove past theories defending lunar volcanism.

Author

In view of the increase of interest in the question of volcanism on the moon, it seems appropriate to review some historical data on the subject. The literature on lunar volcanoes is rather extensive. In the well-known *Bibliographie Astronomique* of Houzeau and Lancaster, published in Brussels from 1882 to 1887, over 80 articles and notes on the subject are listed. Of these, we should turn first to the observations of William Herschel, which were made more than 170 years ago.

Herschel's article, which appeared in the *Philosophical Transactions* of the Royal Society for 1787, is well known, and is given below in the original English.¹

An Account of Three Volcanos in the Moon.

It will be necessary to say a few words by way of introduction to the account I have to give of some appearances upon the moon, which I perceived the 19th and 20th of this month. The phaenomena of nature, especially those

¹An account of three Volcanos in the Moon, by William Herschel, *Philosophical Transaction*, Part I, p. 229, 1787. - Original English version - Tr. note.

that fall under the inspection of the astronomer, are to be viewed, not only with the usual attention to facts as they occur, but with the eye of reason and experience. In this we are however not allowed to depart from plain appearances; though their origin and signification should be indicated by the most characterizing features. Thus, when we see, on the surface of the moon, a great number of elevations, from half a mile to a mile and an half in height, we are strictly intitled to call them mountains; but, when we attend to their particular shape, in which many of them resemble the craters of our volcanos, and thence argue, that they owe their origin to the same cause which has modelled many of these, we may be said to see by analogy, or with the eye of reason. Now, in this latter case, though it may be convenient, in speaking of phaenomena, to use expressions that can only be justified by reasoning upon the facts themselves, it will certainly be the safest way not to neglect a full description of them, that it may appear to others how far we have been authorized to use the mental eye. This being premised, I may safely proceed to give my observations.

April 19, 1787, 10 h. 36' sidereal time.

I perceive three volcanos in different places of the dark part of the new moon. Two of them are either already nearly extinct, or otherwise in a state of going to break out; which perhaps may be decided next lunation. The third shews an actual eruption of fire, or luminous matter. I measured the distance of the crater from the northern limb of the moon, and found it $3^{\circ}57'$, 3. Its light is much brighter than the nucleus of the comet which M. Méchain discovered at Paris the 10th of this month.

April 20, 1787, 10 h. 2' sidereal time.

The volcano burns with greater violence than last night. I believe its diameter cannot be less than $3''$, by comparing it with that of the Georgian planet (Uranus T.K.); as Jupiter was near at hand, I turned the telescope to his third satellite, and estimated the diameter of the burning part of the volcano to be equal to at least twice that of the satellite. Hence we may compute that the shining or burning matter must be above three miles in diameter. It is of an irregular round figure, and very sharply defined on the edges. The other two volcanos are much farther towards the center of the moon, and resemble large, pretty faint nebulae, that are gradually much brighter in the middle; but no well defined luminous spot can be discerned in them. These three spots are plainly to be distinguished from the rest of the marks upon the moon; for the reflection of the sun's rays from the earth is, in its present situation, sufficiently bright, with a ten-feet reflector, to shew the moon's spots, even the darkest of them: nor did I perceive any similar phenomena last lunation, though I then viewed the same places with the same instrument.

The appearance of what I have called the actual fire or eruption of a volcano, exactly resembled a small piece of burning charcoal, when it is covered by a very thin coat of white ashes, which frequently adhere to it when it has

been some time ignited; and it had a degree of brightness, about as strong as that with which such a coal would be seen to glow in faint daylight.

All the adjacent parts of the volcanic mountain seemed to be faintly illuminated by the eruption, and were gradually more obscure as they lay at a greater distance from the crater.

This eruption resembled much that which I saw on the 4th of May, in the year 1783; an account of which, with many remarkable particulars relating to volcanic mountains in the moon, I shall take an early opportunity of communicating to this Society. It differed, however, considerably in magnitude and brightness; for the volcano of the year 1783, though much brighter than that which is now burning, was not nearly so large in the dimensions of its eruption: The former seen in the telescope resembled a star of the 4th magnitude as it appears to the natural eye; this, on the contrary, shews a visible disk of luminous matter, very different from the sparkling brightness of star-light.

Slough near Windsor¹

April 21, 1787.

William Herschel

In this article it is worth noting that Herschel indicates that he has observed volcanic eruptions on the Moon as early as May 1783, and that he intended to make a report on these observations to the Royal Society at an early date. However, he did not make any such report, either that year or in succeeding years.

What did Herschel see in 1783? Studying the correspondence of the Petersburg Academy of Sciences with English scientists, which is preserved in the archives of the Academy of Sciences, we discovered an interesting letter from one of the foreign honorary members of the Petersburg Academy of Sciences, John-Hyacinth Magellan (1723-1790). A descendant of the famous Portuguese navigator, Magellan was born in Portugal (or according to other sources, at Talavera in Spain), but lived in London. In 1774 he was elected to membership in the British Royal Society, and in 1778 became a foreign member of the Petersburg Academy. He treated the Academy with the greatest respect, valued his election to its membership highly, and rendered it a real service by forwarding to it various publications which had just appeared, especially in the physical and mathematical sciences, and communicating all the outstanding scientific news of the day.

Since he was not only acquainted with the scientific community in England, but knew scientists of many other countries with whom he maintained an active correspondence, Magellan was able to pass on quickly to the Secretary of the Petersburg Academy, I. A. Eyler (the son of Leonhard Euler), items of information which often appeared in the foreign press only much later.

¹About 30 km west of London, and the site of Herschel's observatory.

Here is what J. Magellan writes to I. Eyler in the letter mentioned above, dated 28 May 1784.¹

"As to Herschel, you probably already know that he has discovered an active volcano in the Moon. He brought me his observations by his own hand, and I pray you will present them to the Academy. These are his own words, I have simply translated them from English:²

"May 4, 1783.

"In the dark portion of the Moon I perceived a point of light, resembling a star of the 4th magnitude, having a reddish cast; it was located in Hevelius's Mons Porphyrites (Aristarchus- -T.K.). The instrument which I was then using was a Newton telescope with a focal distance of 10 feet and a 9-inch aperture. I could still see it (the point), though only with difficulty, through an achromatic Dollond telescope with a focal distance of 3-1/2 feet; however, persons who could not make it out with the latter instrument, were fully convinced (of its existence) when they looked through the Newton telescope.

"May 13, 1783.

"I perceived two small mountains, conical in shape, which seemed to me to be forming during this last volcanic eruption; they are very close to a third mountain which I have perceived many times at the place; but the two small mountains of which I am speaking I had never seen, and they are not to be found on any map of the Moon, nor even on a drawing of the site which I had made earlier."

"The late Father Beccaria of Turin³ wrote me once that the Moon consistently looked to him as if it were riddled with numerous volcanic craters; how gratified he would be, were he alive, to see his hypotheses verified; and that the observations of his nephews, which he mentions in his letter to Princess Josephine of Savoy, which was published in the Journal de Physique for June 1781, have been confirmed. They had perceived a similar phenomenon during a full eclipse of the Moon on 11 October 1772. This also confirms his hypothesis concerning the observation of Don Antonio d'Ulloa⁴, who, while watching the solar eclipse of 24 June 1778, thought he saw there (in the Moon?) an opening. Monsignor Bianchini⁵ seems to have observed something of the kind; but it

¹Archives of the Academy of Sciences USSR, F. 1, Op. 3, No. 67, leaves 142-143.

²Magellan's letter is in French.

³Beccaria, Gian Battista (1716-1781), abbot and professor of physics at the University of Turin.

⁴D'Ulloa, Don Antonio (1716-1795), a Spanish astronomer, participant in the Great Peruvian Arc Measurement of 1735-1736, member of the London Royal Society.

⁵Bianchini, Francesco (1662-1729), canon, doctor of theology, and astronomer in Rome.

is remarkable that both the nephews of Father Baccaria and Don Antonio d'Ulloa, using nothing but a 1-1/2-foot telescope, were still able to perceive this point of light, which from the estimate of Ulloa himself must have had a diameter of about a league; while Herschel's volcano could only with difficulty be perceived through a 3-1/2-foot telescope; and the moreso in view of the sharpness of vision, accustomed to astronomical observation, which distinguishes all his family."

Here, apparently, are meant precisely those observations which Herschel records in his 1787 article. Let us pause briefly on the observations of Beccaria and d'Ulloa. D'Ulloa perceived during the solar eclipse of 1778 a bright spot near the lunar limb, which according to him was much brighter than the surrounding area, approaching the brightness of the Sun. From this d'Ulloa came to the conclusion that this bright spot was a hole running through the Moon, through which the bright surface of the Sun was visible.¹ This view of d'Ulloa is rebutted by an article by Beccaria, which is excerpted in the *Journal de Physique*. Beccaria declares that d'Ulloa's hypothesis is altogether improbable "by reason of the enormous distance which an opening running through the Moon from one hemisphere to the other would have to span."²

Beccaria appends to this rebuttal a statement concerning a similar phenomenon observed on the Moon during the total lunar eclipse of 11 October 1772, which he explains as the eruption of a lunar volcano. He describes this phenomenon in great detail, although unfortunately he did not observe it himself. He writes in his article that he was preparing to observe the eclipse with a 1-1/2-foot Dollond telescope, when he received a letter from de Saussure (1740-1799), the famous French physicist, requiring him to leave for the city immediately. He therefore arranged for his nephew and niece to make the observations, and on his return his nephew told him that shortly after the eclipse of the Moon became full, a bright spot, reminiscent of a star, had appeared on its disk, and remained throughout the time of the eclipse. The niece was questioned separately from her brother and, independently of him, told exactly the same story.

Becoming interested in this, Beccaria asked his nephew on the following day to train the telescope on the same place, and ascertained that the bright spot was located near the crater named after Copernicus. Beccaria says further that he introduced this observation into the lectures which he read at the university, ascribing it to himself so as not to go into irrelevant details. "During the lunar eclipse of 11 October 1772, using a Dollond telescope belonging to Count de Pertengo, I perceived a point of light on the disk of the fully eclipsed Moon. I can ascribe such a light to nothing other than a volcanic eruption on the Moon; each time I examine the Moon, I cannot regard those long parallel rays which extend from all sides of (the crater) Tycho otherwise than as streams of molten material which have poured out from an enormous volcano..." Beccaria further notes that if his theory is correct,

¹ *Journal de Physique*, Vol. XV, p. 319, April 1780.

² *Ibid.*, Vol. XVII, p. 447, 1781.

such phenomena should be observable during other full eclipses. If they have not been observed up to the present time, Beccaria accounts for it as follows: "When the Moon is in full eclipse... astronomers are prone to relax, supposing that there is nothing further for them to see; it may be, that something as unremarkable as this has prevented them from heretofore noticing these points of light. Now that they are forewarned it may happen that they will observe this phenomenon frequently."

As for Bianchini, he noted a singular phenomenon on the surface of the Moon during a lunar eclipse in Rome on 10 December 1685, i.e., almost 100 years earlier.¹ Bianchini perceived, near the crater Plato or Lacus niger major according to Hevelius, on the border between the lighted and dark sides of the Moon, which was one day past the first quarter, a reddish ray bisecting the entire area within the crater, as though there were an aperture in the side wall of the crater. This phenomenon, according to his theory, could also be explained if the Moon had an atmosphere which reflected light. This observation by Bianchini is cited by Short,² who perceived a similar phenomenon in the crater Plato in 1751 and described it in a brief note, "An Account of a Remarkable Appearance in the Moon, April 22, 1751."³

Besides the letter to the Secretary of the Academy of Sciences, I. Eyler, Magellan wrote at about the same time to the astronomer Bode⁴ a letter concerning Herschel's observations, an extract from which was printed in 1784.⁵

"He (Herschel), using a 20-foot Newton telescope, observed the light of a volcano on the site of the lunar spot Mons Porphyrites (Aristarchus). Father Beccaria thought that the "hole" in the Moon seen by d'Ulloa was a volcano, and that his nephew had seen another volcano in the crater Copernicus during the full eclipse of the Moon in October 1772. Bianchini also observed nothing of the sort on the Moon."

It may further be noted that the famous French astronomer Laland (1732-1807) also sent Eyler a few words in a letter dated 1 October 1785, concerning an eruption on the Moon; mentioning that Herschel was working on his 40-foot telescope, Laland added: "...he (Herschel) actually observed a volcano on the Moon in the form of a peak or cone which developed in 3 or 4 days, and from which two streams or creeks ran out; he discerned a depression or crater; the

¹L'éclipse totale de la Lune observée à Rome (The Total Eclipse of the Moon Observed in Rome), Acta eruditorum, Leipsig, 1686.

²Short, James (1710-1768), English astronomer and astronomical instrument designer.

³Philosophical Transactions, p. 164, 1751.

⁴Bode, Johann Elert (1747-1826), astronomer, director of the Berlin Astronomical Observatory, and publisher of the Berliner Astronomisches Jahrbuch.

⁵Berliner Astr. Jahrbuch für 1787, Berlin, p. 252, 1784.

flame was visible even by ashen light, or on the dark side of the moon." Probably here it is still a question of the same observation of Herschel of May 1783, although Laland's description does not agree with the one Magellan gave directly from Herschel's own words; the date of the observation is not indicated in Laland's letter.

Magellan's letter stirred great interest in the Petersburg Academy, where it was presented on 14 June 1784. Evidently, no doubts as to the reality of the eruption observed by Herschel arose at that time. The well-known Petersburg academician Aepinus (1724-1802) also commented on Magellan's communication; he published an article¹ in the form of a letter to Academician Pallas (1741-1811), in which he hails Herschel's observation as a confirmation of the hypothesis of the volcanic origin of lunar mountains. In this article he states that the first to enunciate this hypothesis was the celebrated Robert Hooke² and proposes that the new volcano discovered by Herschel be named after him.

But the volcanic theory of the origin of lunar mountains and the assumption that active volcanoes exist on the Moon are far from the same thing; if of course, Herschel actually saw the eruption of a lunar volcano, this would be a weighty argument in favor of the volcanic theory.

However, by the beginning of the 19th century, astronomers were already critically regarding the hypothesis of eruptions on the Moon. In this regard it is interesting to note the letter of Olbers³ to John Herschel, read at a meeting of the London Astronomical Society on 13 April 1821.⁴

"On the 5th of February 1821, I observed a remarkable light phenomenon in the dark part of the moon; concerning which Captain Cater has communicated to the Royal Society.⁵ According to my understanding, Captain Cater is convinced that this was a volcano in a state of eruption, but I must admit that I cannot bring myself to believe in the existence of any sort of volcanoes on the Moon; and I submit that this very remarkable phenomenon may be satisfactorily explained in some other way more in agreement with what we know about the physical structure of the Moon. This light phenomenon (the one described by Cater) was

¹Aepinus, Lettre à Pallas sur le volcan de la Lune (Letter to Pallas on the Volcano in the Moon), Nova Acta Acad. Petropolit., V. XII, 1784.

²Hooke, Robert (1635-1703), physicist and astronomer, secretary of the London Royal Society. He discusses lunar volcanoes in chapter LX of "Micrographia", London, 1655.

³Olbers, Henrich-Wilhelm (1758-1840), physician and astronomer, the author of many works on astronomy, especially on comets.

⁴Memoirs Astr. Society of London, V. 1, pp.157-158, 1822.

⁵Cater, Henry (1777-1835), astronomer and mechanical engineer, participant in topographic surveys in India. His article on volcanism on the Moon was printed in Philosophical Transactions, p. 130, 1821.

observed, I understand, in the spot called Aristarchus, or near it. This Aristarchus (as is well known) is always lit up by the Earth against the dark surface of the Moon when it is 3 or 4 days old; its brightness distinguishes it from all other lunar spots. However, the bright glow of February 5th was entirely different from the usual appearance of Aristarchus, with which I am quite familiar, and had the brightness of a star of the 6th magnitude in my 5-foot achromatic Dollond telescope. I will shortly publish my views on so-called lunar volcanoes..."

In this connection, V. Ya. Struve¹ wrote:

On the 27th of January of this year, I too observed the phenomenon of so-called lunar volcanoes. Near Aristarchus shone a point, reminiscent of a star of the 8th magnitude, seen through a light overcast. I am fully in agreement with the explanation of this phenomenon given by Olbers.²

Subsequently, Olbers actually enunciated his views on lunar volcanoes in more detail, even adding a few new considerations.³

"I have just had the pleasure of acquainting myself with Captain Cater's report of the light phenomenon which he observed in the dark part of the Moon on 4 February 1821, and have convinced myself that this so-called lunar volcano is the same phenomenon which I observed on the following day, February 5th. I explain this phenomenon, often observed in "Aristarchus", as perhaps you have seen in the Göttingen Gelehrte Anzeigen, as being a partial reflection of light coming from the sun-illuminated Earth by the smooth lateral wall of the high cliff (Felsklippe) belonging to Aristarchus; such reflection occurs during a certain libration. On the basis of what we know about the properties of the Moon and its atmosphere, I cannot believe in actual active volcanoes, but I must in any case mention an extraordinarily important observation which was communicated to me by the younger Herschel with the permission of the observer.⁴ This is the observation of Mr. Brown, which definitively indicates a volcanic eruption in the spot Aristarchus, which took place in February 1821. To be precise, Mr. Brown some years ago distinctly noted in Aristarchus two small black openings or depressions, one of which apparently was gradually filling up; however, after this last eruption, both openings disappeared without a trace, and in their stead an elevation is visible. Mr. Brown also noted a band of unusually white material which had not previously been there, running out from the spot. If this great change in the spot Aristarchus is confirmed after February of the present year, then at least for the present, my explanation will be irrelevant. But first it must be carefully investigated as to whether the former appearance of Aristarchus will not reappear, i.e., both openings, the absence

¹Struve, Vasilii Yakovlevich (1793-1864), astronomer, academician, and first director of the Pulkovo Observatory.

²Astronomische Nachrichten, p. 138, 1823.

³Berliner Jahrbuch, p. 228, 1824.

⁴Herschel, John (1792-1871), son of William Herschel, and a famous English astronomer.

of the white band, and so forth, when a different libration and a different angle of illumination are obtained. It is, of course, well known how the appearance of one and the same lunar spot varies with different librations and different angles of illumination; thus, the illustrations which the careful Schreter¹ has given us in his *Fragmente* are almost totally inconsistent with one another. In short, it is still necessary to elucidate preliminarily whether the reason for the observed changeability of the appearance of Aristarchus actually lies in physical changes, or whether it is governed by optical laws.

On the same day, February 5th, that I observed Aristarchus in the form of a star, Professor Garding² saw it as a cloudy spot. Probably this is attributable to the fact that he used a telescope with a magnification of 132 times, while I, having prepared myself to observe a comet, was using only the 44-power magnification of my Dollond instrument. Thus, even planetary clouds, as for example in Aquarius, appear at low magnifications like fixed stars, and at higher magnifications like clouds."

Here Olbers, although he mentions the need of care in settling the question of lunar volcanoes, nonetheless is ready to admit that Braun's observation differs somewhat from the usual optical illusions by which Aristarchus quite frequently leads astronomers astray.

As we have seen, it was precisely in Aristarchus (Mons Porphyrites) that Herschel observed his "active volcano." Have we tried to explain what was his final viewpoint concerning this phenomenon? As we will see further on, several authorities assert that Herschel renounced his volcano theory and came to the conclusion that he had been the victim of an optical illusion. However, neither in his own writings nor in biographies of Herschel are there any direct indications of this. In Holden's book, "W. Herschel, His Life and Works", New York, 1881, there is only a brief mention of Herschel's article, "The Mountains on the Moon", 1780: "...after which he occupied himself but little with our satellite. The observation of volcanoes (1787) and a single lunar eclipse were all that he published (concerning the Moon)" (p. 140).

Holden also cites a few details concerning Herschel's observations of 4 May 1783:

"In 1787 Herschel wrote his article, "An account of three Volcanos in the Moon," which he had observed in April. In it he mentions earlier observations of the same nature. I do not recall whether the following

¹Schreter, Johann Hieronymus (1745-1816), astronomer in Lilienthal; his *Selenotopographische Frangmente* were published in 1791.

²Garding, Karl Ludwig (1765-1834) occupied the Chair of Astronomy at the University of Göttingen.

communication concerning these observations appeared in English at some time. Baron von Zach¹ wrote to Bode from London (Jahrbuch, 1788, 144):

"Probably you have also heard about the volcanoes on the Moon observed by Herschel.... I will give you an account of what I heard about them from his own lips. Dr Lind², the respected Windsor physician, who won renown with his travels in China, and who was Herschel's friend, was visiting them one evening at Detchet (4 May, 1783). A certain star was due to be occulted by the dark disk of the Moon during the evening. Herschel and Dr. Lind observed the occultation. Mrs. Lind also wanted to take a look at what was happening, so she came to the telescope and began to gaze attentively through it.

"No sooner had the star disappeared from view, when it seemed to Mrs. Lind that she saw it once more, and she exclaimed that the star was in front of the Moon, and not behind it. This occasioned a short lecture on the point at hand, but she would not hear of it, because with her own eyes she had seen otherwise. Finally, Herschel looked through the telescope, and actually saw a bright point on the lunar disk, which he began to follow attentively. The point gradually became faint, and finally disappeared"... ." (pp. 69-70).

Soon after this Herschel visited Magellan (pp. 78-80), and here, apparently, the latter heard from Herschel what he later wrote in his letter of 28 May 1784 to I. A. Eyler.

In the large Encyclopedia Americana, published by the Americana Corporation (New York, Chicago, 1929-1953, Vol. 14, p. 151), we find an entirely erroneous statement: "In 1783, he (Herschel) believed that he had discovered a volcano on the Moon, but on the basis of later observations conducted in 1787 he concluded that he had been the victim of an optical illusion."

This is not true. On the contrary, it was precisely in 1787 that Herschel published his article, "An Account of Three Volcanos in the Moon", with which we commenced our exposition. It is true, as we have seen, that in the beginning of the article he emphasizes the difference between "pure observation" and "reasoned explanation", i.e., expresses some doubt as to the origin of the phenomena he had observed; but this does not, of course, constitute outright abandonment of his earlier viewpoint.

We will notice that the wording of his later note concerning the eclipse of 22 October 1790 is much more cautious. The latter is part of an article entitled "Miscellaneous Observations", and was subtitled by Herschel "Remarkable Phenomena in an Eclipse of the Moon:"³

¹Zach, Franz Xavier (1754-1832), engineer and astronomer, and director of an observatory which he established near Gotha.

²Lind, James (1736-1794), physician, meteorologist, and astronomer.

³Philosophical Transactions, p. 27, 1792.

"On the 22nd of October 1790, while the Moon was fully eclipsed, I examined the lunar disk with a 22-foot reflector having a magnification of 360 times. In several places I perceived a number of bright, red points of light. The majority of these were small and round. The brightness of the Moon, although its light was dimmed by the eclipse, prevented me from observing them long enough to determine their position. There were very many of them; I believe that I saw no fewer than 150 of them. Their brightness was a bit greater than that of Hevelius's Mons Porphyrites.

"We know too little about the surface of the Moon to be able to embark on the construction of a hypothesis concerning the possible reasons for the great brilliance, similarity, and remarkable color of these points."

Let us consider in detail Arago's¹ question, of interest to us, which he raised in his 1871 biography of Herschel, published in 1871:²

"At the end of 1787, Herschel presented to the Royal Society a memoir, the title of which should have produced a sensation. In it the author states that on April 19, 1787, he observed, in the dark part of the Moon--that is, in the part which was dark at that moment--three volcanoes in a state of eruption".

Arago discusses Herschel's article further, describing the 1787 observations, and then raises a question of his own:

"How does it come about, that after such precise observations, only very few astronomers will now admit the existence of active volcanoes on the Moon? I wish to explain this in a few words.

The different parts of our satellite do not reflect light uniformly. In some cases this may be because of the form, in others because of the composition of the material (soil). Those who have observed the Moon through a telescope know how great the differences occasioned by these two causes can be, and how one point on the Moon can sometimes appear much brighter than those surrounding it. It is quite evident that the relative intensity of these dark and light parts must continue to exist, whatever the means by which they are illuminated. In the parts of the lunar disk illuminated by the Sun, there are, as is well known, certain points whose brightness is extraordinarily greater than that of the surrounding surface; it is these points which, when seen in that part of the Moon which is illuminated only by light reflected from the Earth, i.e., in the region of ashen light, will always dominate the surrounding area by reason of their comparative intensity. In this way it is possible to explain the astronomer's observations at Slough without resorting to volcanoes."

¹Arago, Dominique François Jean (1786-1853), French astronomer, and the author of biographies of many outstanding astronomers and physicists.

²Report of the Board of Regents of the Smithsonian Institution, Washington, p. 215, 1871.

Arago also cites the extract just quoted from Herschel's observations during the eclipse of 22 October 1793, and comments further:

"But is not red the usual color of the Moon during eclipses, when it is not wholly obscured? Is it not possible that the sun's rays, reaching our satellite by refraction after having undergone some absorption by the lower layers of the atmosphere, might take on some such other coloration? Are there not visible on the Moon, when it is fully illuminated and opposite the Sun, from one to two hundred small points, remarkable for the brilliance of their light? Is it possible that these small points would not be discernible on the Moon when the latter is receiving only that fraction of the Sun's light which has been refracted and colored by our atmosphere?."

The American magazine, *Sky and Telescope*, in 1956 reprinted Herschel's 1787 article under the title "Herschel's Lunar Volcanoes,"¹ without any commentary, and unsigned; only the following editor's note was appended to the end of the article:

"In the present instance the great observer was mistaken, since it is clear that his "active volcano" was the interior of the crater Aristarchus, which is easily visualized as bright spot against the surface of the Moon when, being in the western part of the sky soon after the new moon, the latter is dimly illuminated by the Earth. Herschel's observations of April, 1787, were conducted when the Moon was 2 to 3 days old, and those of 4 May, 1783, when the Moon was 3 days old.

"It should be noted that Herschel clearly distinguishes between "facts as they occur" and "conclusions from observations." The promised future communication to the Royal Society, indeed, was never published, as though Sir Herschel himself acknowledged his mistake. It may be that this mistake was the reason for Herschel's abandoning study of the Moon. He never wrote anything further concerning the Moon."

Thus, although in the literature there is no direct indication that Herschel renounced his hypothesis of lunar volcanic activity, it may still be concluded, on the basis of his declarations quoted above, that he subsequently ceased to maintain it.

We have already noted that in the scientific journals of the 18th and 19th centuries, many articles appeared on volcanoes on the Moon, described by many observers at various times. No doubt, many of these observations are explained as mere optical illusions; this is discussed in detail by L.S. Copeland in the magazine *Sky and Telescope*² in an article on "Illusions that trap the lunar observers." But are they all illusory? We have seen,

¹"Herschel's Lunar Volcanoes," *Sky and Telescope*, p. 303, 1956.

²"Illusions that trap the lunar observers," *Sky and Telescope*, p. 248, April 1956.

for example, how even Olbers drew a distinction in his articles between earlier observations of Aristarchus, already known to him, and the observations of Braun, communicated to him by J. Herschel, which he considered especially worthy of attention.

The article of N. A. Kozyrev,¹ and the observations of D. Olter which preceded it in 1956, have caused some astronomers to turn to the more plausible of the old accounts of changes in the lunar surface. Thus, the German astronomer Hans Kaiser, in the journal Kosmos², citing a number of cases when changes hardly appeared to be the result of optical illusion, writes: "...at the same time there do exist considerable changes in the reality of which it is hardly possible to doubt"; and proceeds to cite the opinions of a number of eminent modern investigators of the Moon. He concludes his article with the words: "The observation of a volcanic eruption in Alphonsus is thus not so much the sensational discovery it was represented to be in some sectors of the daily press, as it is a new confirmation of earlier observations and the conclusions drawn from them." Future observations of the Moon, using all the modern equipment at the disposal of astronomers of all countries, cannot help but furnish an answer to the important question of the volcanic activity of the Moon.

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¹"Volcanic Activity on the Moon," Astronomicheskiy tsirkulyar, No. 97, 1958.

²Kosmos, No. 2, 1959.